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BRITISH ASSOCIATION OF GAS MANAGERS.

EIGHTEENTH ANNUAL MEETING.

INAUGURAL ADDRESS OF THE PRESIDENT, CHARLES HUNT, ESQ., M.INST.C.E., OF BIRMINGHAM,

DELIVERED TUESDAY, JUNE 14, 1881.

IT is my pleasing duty to return you my sincere thanks for having placed me in the honourable position of President of an Association of such great and growing importance, which year after year continues to establish new claims upon our attachment, and is destined, as I hope and believe, to furnish yet more convincing proofs of capacity for development and useful work.

If the pioneers of our industry could be with us to-day, I venture to think that with the gratification they would experience at witnessing this assembly, representative as it is of a growth such as the most sanguine of them could never have anticipated, would be mingled a feeling of justifiable pride at the position now assigned, by the almost unanimous voice of entire communities, to the system of artificial illumination which they so potently called into existence. For it was their lot to conduct a difficult and doubtful enterprise to questionable success; to lavish their resources of time, ingenuity, and money, for a very inadequate return. Theirs, it is true, was the satisfaction that belongs to those who are permitted to follow the bent of their genius; to sow the seeds of new industries; and to watch for the first signs of life in the quickened germ; but for a later period was reserved the spectacle of the abundant harvest. We of that period are privileged to dispense the advantages resulting from those early efforts; and, let us hope, to lay the foundations of further and more important benefits.

As a natural consequence of the position which coal gas has acquired as a necessity of modern life, it has followed that the arrangements for its supply have become matters of growing public concern. They have come to rank almost with those for the supply of the commonest necessaries, and are canvassed with an eagerness second only to that which is provoked by the incidence of taxation. Such being the case, it is not to be wondered at that a conflict should have arisen between the representatives of private enterprise on the one hand, and of local self-government on the other, the ultimate termination of which has hitherto been found only in the assumption by the latter of the duties and responsibilities initiated by the former. This very general result, it is almost needless to say, has been greatly accelerated, if not entirely brought about, by that extended application, contemporaneously with the advance in the fortunes of Gas Companies, of the principle of popular representation as applied to municipal government, which dates from the passing of the Municipal Corporations Reform Act of 1835. That Act, which has not inaptly been called the Great Charter of the Municipalities, could not fail of being the precursor of notable changes, although it was not to be expected that these would be immediately apparent. The free institutions thus created were not all at once to be endowed with vigorous manhood. They were destined to encounter all the perils of immaturity and inexperience, and won their way slowly, though surely, to public confidence. But time has amply vindicated the wisdom of their authors. If local self-government has not yet ceased occasionally to provoke a taunt from those whose sense of ridicule is stronger than their sense of patriotism, at least it must be admitted to have contributed most materially to the comfort and happiness of the population of our great towns.

It does not, however, fall within the scope of the observations that I am privileged to address to you, to dwell upon either the merits or the demerits of municipal institutions, although I may be permitted to pay a passing tribute to the eminent services rendered to their cause by a former Chairman of a Gas Committee. I allude, as may be supposed, to the Right Hon. Joseph Chamberlain, M.P. The mention of this gentleman's name will appear to be none the less appropriate from the fact that he may be said almost to have commenced his public career as a gas administrator. It is not too much to say that by his example and precept the work of local administration has acquired new significance and strength, and a breadth and dignity hitherto to a great extent lacking. If hereafter it should be determined still further to extend the power and authority of Municipal Councils, and so relieve the already overburdened national legislature, such a result will have been in no small degree owing to the spirit infused into their deliberations by the right honourable gentleman and his coadjutors.

It is upon the final aspect of the struggle to which I have referred—or that in which the gas undertakings, after what may be described as a vicarious existence, have passed into the hands of the Local Authorities—that I desire, in the first place, to say a few words; being emboldened to take this course from the circumstance that, as regards the office which I have the honour to occupy, this happens to be the first time that your choice has fallen upon the representative of a Corporation. The subject is one that it cannot be desirable should be approached in any spirit of partisanship, for this would be foreign to the work of the Association. Neither do I feel myself fitted for such a task; my present experience and associations being somewhat at variance with those of earlier and perhaps more impressionable years. But in the consideration of certain principles involved in this change of ownership, and, above all, of the prospects of gas lighting in the hands of its new masters, all of us—representatives of Companies and Corporations alike—are interested, and are able to meet upon common and neutral ground.

It may, then, be accepted as no slight testimony to the strength and character of popular representation, that it should be entrusted with the conduct of important industrial and commercial enterprises; and especially will this be felt when it is recollected that there exists in this country no precedent for the assumption, by the governing bodies, of the functions and position of private traders. Nor could such assumption be justified, except upon the high ground of public convenience and advantage. Not that the Gas Companies had in any way failed in the performance of the duties they had undertaken. On the contrary, they had served the public faithfully and well. They had performed all, and occasionally more than all of their statutory obligations. The convictions, under their penal clauses, throughout the entire kingdom had scarcely amounted to as many during the number of years that they had been in force, as are obtained in a single year against the law-loving and law-

abiding citizens of Birmingham under the Acts for the Prevention of Smoke. It could have been through no fault of theirs, but rather the reverse, that the article they supplied had grown from exceptional into almost universal use. It could have been through no fault of theirs, but rather the reverse, that they ultimately became prosperous. Neither could it have been justly charged against them that there had sprung up an impatience of privileged monopolies, increasing in intensity with the growing strength of the governing bodies. Nevertheless, it is in consequence of this combination of results that we find ourselves in contemplation of a movement which, in a comparatively short space of time, has, in most of our great centres of population, displaced the Companies in favour of the Local Authorities. And thus far there has been no reason to regret the change. On the part of the Corporations there has been uniformly manifested a disposition to pay a fair, and even a full price for the property they were desirous of purchasing, and this has been met by the Companies with a patriotic willingness to accept such terms; the result being that to the public have been secured the benefits of co-operation in its widest and most significant sense, and for gas lighting what may fairly enough be regarded as almost the highest pinnacle of importance.

I have said that the justification for these transfers is furnished by their promotion of the public convenience and advantage. For example, the desirability of securing to one central authority the undivided control of the thoroughfares, would seem to be self-evident; yet some are inclined to pay little heed to the objections urged by Local Authorities to the breaking up of the streets by an independent, and in some respects a rival power. The inconveniences arising therefrom they regard as imaginary; the grievance as sentimental, inasmuch as Parliament has provided in its enactments for the restoration, at the cost of the Companies, of all damage occasioned by them. But having been myself the instrument, during the last few years, and under both *régimes*, of about as much of this particular kind of "street disturbance" as falls to the lot of most gas engineers, I am enabled, perhaps in a peculiar degree, to bear testimony, not alone to the somewhat trying conditions under which the work of a road-mender has to be carried on, but also to the advantage, from an economical point of view, of that unity of action which is, or ought to be secured, when those whose operations are of so divergent a character no longer rank as representatives of opposing interests, but are engaged side by side in one common service. At the same time I feel bound to admit that in my own case one bone of contention still remains. I have never been able to persuade my esteemed friend, the Borough Surveyor of this town, to relinquish, in the interests of the gas undertaking, the use of that pernicious instrument, the steam roller!

It is commonly objected that the ruling motive of the Corporations in making these acquisitions, has been one of profit. They would not, it is alleged, have sought to displace the Companies had gas manufacture continued unremunerative. It was only as this became otherwise that they awoke to a sense of their responsibilities. There is much of truth in this, but of truth that cannot be, in any strict sense, a reproach. Even assuming the opposite of what we know to have been the case—namely, that the governing bodies were, from the first, fitted to undertake the management of the gas supply—their hesitation, in all but a few instances, was not without justification. We all know that coal gas was, for a lengthened period, upon its trial. It was held in doubtful esteem. It was looked upon with coldness, amounting almost to aversion, by men of high scientific attainments; and was even in some degree of danger from the favour with which they regarded a more brilliant and attractive rival. That danger has not ceased to recur, and was probably never more real than now; but then its influence to-day is more than counterbalanced by an assurance as to the future of gas lighting, solidly based upon a more just appreciation of its resources—as yet imperfectly developed—and of the strength and vigour to which it has so rapidly attained. But in the absence of such assurance, the materials for which are of a comparatively recent growth, it would have been both imprudent and impolitic to have adventured the public money in the purchase of these undertakings. It would have savoured too much of speculation—a course which, in regard to public funds, all are agreed in condemning. The employment of such funds, however, for purposes of general utility—as, for example, the establishment of the postal system or the purchase of the telegraphs—has, with equal unanimity, been recognized as not only perfectly legitimate, but even necessary to the general welfare. Nor can it be denied that the same public opinion which placed these two great branches of the national service under the conduct of the State, eventually—although exercised, according to the circumstances, in a more limited sense—decided upon the principle to be applied to gas supply. That principle may be accepted as a maxim of good government; for it declares that profit derived from indispensable monopolies should revert, not to individuals, but to the community by which it is contributed.

Having succeeded to the possession of these flourishing undertakings, Corporations at once become the objects of a most touching solicitude. The greatest anxiety is manifested as to their deportment under the trying, albeit not unpleasing embarrassment of a balance on the right side. "What will they do with it?" is the inquiry from all quarters. What they ought to do with it is, according to the opinion of an influential section of their critics, clear enough. Of course, it is somewhat dogmatically asserted, they ought to apply it to a reduction of the price of gas; and so much satisfaction seems to be derived from this doctrine, that any appearance of disregarding it is visited with severe reprobation. Now, I do not happen to be one of those who conceive it to be within the province of the officials to tender advice as to the disposal of gas profits. That is a matter which may very safely be left to the discretion of the representative bodies, who are answerable to their constituents for their financial policy. Our chief, not to say sole duty lies in the pursuit of means for the attainment of the most economical ends. Our satisfaction is derived from the achievement of results. It is our privilege to create—at all events in a very great measure—the situation from which it is the task of others to work out a more or less satisfactory deliverance. But every individual may have something to say upon such a topic; and most of all we who have thrown in our lot, so to speak, with the fortunes of gas enterprise; while it is not unnatural that our opinions should be biassed in favour of the policy which promises most for the extended use of gas. So remotely, however, does it concern us whether the object of the Corporation be to sell gas at cost price or to relieve the rates, that, in our official capacity, the course that appears to me to be most properly ours is one of non-intervention.

Especially will this be felt when it is recollected how varied are the conditions that must affect the decisions of the Local Authorities, rendering almost nugatory any definition of a general principle, and also how absolute is the control of the consumers themselves. The consumers, in fact, are the masters of the situation. They constitute a large and influential majority of the ratepayers. They have it in their power to impose their will upon the management of the gas supply. They may, if they choose, legislate solely in the direction of their own immediate interests. They may, and frequently do, determine to supply themselves at the lowest possible price, regardless of the interests of that larger constituency in which are numbered every householder and every owner of property within the limits of the township to which they belong. I cannot but think that it is creditable in them, when other counsels prevail, when they acknowledge their indebtedness to the wider constituency of which they form the greater part; when they recognize the claims of the property which has been pledged for their benefit. For it can hardly be denied that if there be any advantage in Corporation management, it is by virtue of the machinery of self-government, of which the ratepayers are the components, thus brought into more active exercise.

The economies by this means made possible are, some of them, more indirect than apparent, although on that account none the less real; while others are tangible enough. There is, for example, the comparatively trifling one effected by the substitution of unpaid Committees for paid Boards of Directors; but a far more important one is that which arises out of the easier terms upon which the necessary capital can be raised by means of the security of the rates. The difference between the cost to the Companies of their capital, and the interest at which Corporations are enabled to place their loans—or, in other words, the difference in value, according to public estimation, of the two kinds of securities—is in every instance considerable, although varying with circumstances. Take, for example, the case of the Metropolis. According to the latest published accounts, the entire share and loan capital of the four remaining Companies supplying gas within its limits, as represented by its market value, amounts in round figures to 20¾ millions sterling, which will be found to yield to investors an average return of 5½ per cent. On the other hand, Metropolitan Board of Works' stock yields only a trifle over 3⅛ per cent., and this may be safely taken as the rate at which any new loans could be negotiated. The difference between this and the average interest upon the gas

stock is 2¾ per cent.; which, upon the capital of the Companies, represents a sum of no less than £493,896 per annum, or 6·5d. per thousand cubic feet upon the gas sold. Doubtless this is a somewhat extreme case, the difference in the provinces being usually less marked; while, as a matter of course, it is impossible that any similar saving could be effected as the immediate result of a change of ownership. But it indicates a way by which Corporations might, if they chose, and if the law permitted them, participate in the profits of these undertakings, and even secure a certain amount of control over them without incurring the responsibilities of sole ownership—namely, by the investment, within certain limits, in gas stocks, of funds raised upon the security of the rates, after the manner of similar investments in docks or other public works of a remunerative character. Whether such a course, as recently proposed, in fact, by the Metropolitan Board of Works, upon the application of a Water Company for additional capital, would tend to the satisfactory settlement of what is still, to some extent, a vexed question, it is probably not yet entirely beyond the reach of events to determine. The main purpose, however, of this reference to the Metropolis is to exhibit the nature and possible extent of an economy rendered practicable only by the action of the ratepayers; and towards which the consumers, as such, are in no sense contributors. In common fairness, then, it seems only right that some return should be made to the former; and yet, when the consumers, of their own free will, as is abundantly manifest, from their numbers and influence, elect to be equitably taxed in recognition of their obligations to the responsible owners of the undertakings, the cry is raised, ostensibly in their interest, although clearly not with their concurrence, that they are being treated unfairly and oppressively, in a manner contrary to the principles that should guide the councils of the Municipalities.

I know it is argued that Corporations have no right to make profits, and, if I am not mistaken, the opinion of more than one high legal authority has been expressed to this effect. I hope, however, that it will not be considered presumptuous in me if I ask—By what law is this expressly forbidden? Is it held to be contrary to the letter, or to the spirit only of our statute-books? If to the letter, then it is plain that the remedy is a weapon that can at any time be wielded with effect against the Corporations; but if to the spirit, then I venture to suggest that this is susceptible of more than one interpretation. It is not at all difficult to agree with limitations that have for their object the prevention of competition between public corporations and private traders, although the latter are generally secure enough in the hands of the constituencies. Nor is it easy to conceive of parliamentary sanction being extended to Corporation enterprise undertaken for the sole and ostensible purpose of profit; but clearly a distinction must be drawn between profit that might be so derived, and that which may accrue from the performance of a necessary public service. For instance, any endeavour to extend the operations of the Government Savings Bank or Life Insurance systems is sure to meet with opposition not wholly confined to the interests most immediately affected; and one can understand, if not appreciate the jealousy with which such innovations are regarded. They interfere somewhat with the course of private enterprise, which, in matters of this kind, it is not absolutely essential, however desirable it may be to the public welfare, should be displaced by, or be put into competition with the State. But I do not suppose that there is to be found one British taxpayer who grudges the Government the surplus revenues of the Post Office. I will go further, and say that there is not one in ten who does not wish that the annual profit from this source could be increased tenfold, consistently with the maintenance of equal public facilities. The reason for this is not far to seek. The monopoly enjoyed by the Post Office interferes with no one. It accomplishes that which not any amount of competition could improve upon. In no other transaction in life is the taxpayer secure of such a cheap pennyworth, or, I should say, halfpennyworth. And in no other way could the expenses of the State be more easily and imperceptibly met. The Chancellor of the Exchequer, who may hereafter devise so facile—I had almost said charming—a method of augmenting the national revenues, will well deserve the gratitude of his countrymen.

But, it will be asked, "What has this to do with the question of gas profits?" My reply is that in the disproportion that exists between the value of the service rendered, and the almost nominal charge for such service, the case of the Post Office is not entirely without a parallel, since, in nearly every instance, gas lighting is worth, intrinsically, much more than is charged for it. The ordinary consumer knows very well that he cannot replace it with its equal for convenience and economy. It would require, indeed, a very considerable advance upon present prices to put in jeopardy, or even to render uncomfortable, the existence of any gas undertaking of moderate importance. But a kind of fictitious value—if I may employ the adjective to express a meaning the reverse of that which is its generally accepted one—has been imposed upon gas by means of the restrictions to which from time to time its purveyors have had to submit. It is true that these restrictions are to be regarded in some degree as in substitution of competition; but it is also true that they have operated more favourably to the consumer than the keenest competition that ever existed amongst gas undertakings. In the hands of Corporations these limitations as to profits disappear or become inoperative; because in lieu thereof there arises a most effectual barrier against abuse in this direction—I refer to the public voice. And when that voice declares itself in favour of the policy of ensuring a moderate profit upon the gas supply—such profit to be devoted to the extinguishing of Corporation indebtedness, or to the relief of the rates, or to any other purpose affecting the general interests of the entire community—I, for one, not only fail to discover any impropriety in its utterances, but am fain to regard these as evidences of sound judgment and political capacity.

It is not to be inferred from these observations that I desire to be understood as seeking to defend the making of profit as a primary, or even as an inseparable object. On the contrary, it appears to me impossible to doubt but that there is between the positions of a Company and a Corporation an essential difference; the avowed purpose of the one being that of gain, while that of the other should be the common good. In this view it follows that, wherever the administration of a Corporation is conceived in an absolutely commercial spirit, there the full significance of the movement which placed the gas supply in their hands has not been grasped. In the pursuit of a successful balance-sheet, quite as much as under the influence of what is styled "officialism," there is the temptation to be resisted of imposing restrictions such as are unknown in ordinary commercial transactions, the tendency of which is to narrow the circle of consumers, and to withhold from the masses of the constituencies those blessings of cheap light and heat which it is in the power, and ought to be the valued privilege of their representatives to dispense with a prudent and liberal hand.

Other considerations affect us yet more nearly. It must be admitted that, as regards the extension of the uses of gas and the progress of its manufacture, an additional stimulus has been imparted by the aspirations of the Local Authorities, because these, whatever form they may assume, inevitably furnish the strongest possible motives, not only for increased consumption, but also for intelligent and economical management. Not that Corporations are at all singular in these respects, thanks to the tendency of modern legislation, although no instance has yet been supplied of progress made by a Company working under the provisions of the sliding scale, at all comparable with that which, during a corresponding period, has been achieved by some few Corporations. Neither has the pursuit of economy by Corporations been uniformly attended with the happiest results, for reasons that are sufficiently intelligible; but it is none the less true that these acquisitions, by establishing a practical identity of interests between producer and consumer, have marked the commencement of a new era in the economical advancement of gas lighting. At the same time, and bearing in mind the instances in which Corporation management has been upon its trial for a tolerably lengthy period, it is not to be denied, be the cause what it may, that if the course of gas manufacture has, during the past few years, been marked by any real improvement, little, if any, of this is attributable to the action of Corporations. It has, indeed, been urged against them that their profit-making proclivities have led them to ignore improvements which, when in opposition to the Companies, they had regarded as essential to the interests of the consumers; although, if I might offer to this accusation the reply that is dictated by my own experience, I should give it an emphatic and unqualified denial. I cannot, in fact, conceive of a more vigorous surveillance than that which is exercised, on behalf of the consumers, by a vigilant Corporation in the ordinary discharge of their functions; nor of a more sensitive regard for the wants, and I might almost go so far as to add the fancies of their customers. Those who are inclined to condemn Corporations because, occasionally, complaints are made against their administration, or in opposition to the policy of the majority, would do well to remember that the atmosphere of free discussion, whether through the

medium of the public Press or in the Council Chamber, is as essential to the life and vigour of municipal as to that of national government. It no more follows, because Corporations do not succeed in pleasing everybody, or in eliminating every source of complaint, that therefore they must be pursuing a mercenary and arbitrary policy, than it is to be inferred, from the existence of an active opposition in Parliament, that the Government of the day are not acting with a zealous regard for the well-being, and in harmony with the wishes of the majority of the nation.

As instancing the slender grounds upon which such criticisms are sometimes based, may be mentioned the controversy with regard to purification from sulphur compounds. How often has it not been pleaded, as a reason against the observance of a high standard of purity by Companies, that Corporations are in the habit of neglecting such observance. Yet what are the facts? Is it not a fact that agitation upon this question has been almost exclusively confined to the Metropolis? Is it not a fact that no instance can be cited of a Corporation or Local Authority having deliberately abandoned the standard of purity which they had been the means of enforcing against their predecessors? And is it not also a fact that in at least one conspicuous instance recently the Corporation have themselves taken the initiative, and become earnest in their endeavours to improve upon the method of purification which they may be said to have inherited from the former proprietors of the works?

If we should seek for other reasons to account for paucity of initiation on the part of Corporations, one such reason may probably be deduced from the estimation which the public have learned by degrees to attach to the art of gas manufacture. As their appreciation of the article itself has increased, so their respect for the methods of its production may be said to have declined. "Gas-making," it was observed to me not long since, "is a very simple process." "It appears so," was my reply, "until one begins to know something about it." Does not this little episode faithfully reflect the current of intelligent public opinion on the one hand, and on the other the common experience of gas makers? To men of real scientific culture our manufacture has appeared so absurdly simple that it is impossible to say how much it may have suffered from their neglect; while to others it has also appeared so simple that in our time there have never been wanting volunteers to remind us of our shortcomings, and who know so much better than ourselves how to conduct the business of a gas undertaking with economy and success. It is not needful to recall to your recollection the recent discussion upon a subject that is, without doubt, of increasing importance to all dwellers in large towns—namely, the avoidance of smoke as a means of preventing fogs—as illustrating the extent of unconscious misconception that unfortunately prevails, in otherwise well-informed circles, with regard to the economics of gas manufacture.

With this misconception we are all of us sufficiently familiar. Encouraged as it has been by the almost uninterrupted prosperity of the Companies during a long series of years, it has assumed a variety of phases, and has been attended with consequences most diverse. Gas proprietors have been led to seek for their dividends as the result mainly, if not entirely, of a series of ordinary commercial transactions. They have been content, for the most part, to know that their materials have been purchased in the cheapest, and their products sold in the dearest markets. This feeling is likely to be intensified in the case of Corporations, because they would be predisposed to regard gas manufacture as pertaining to the nature of an exact science. Their justification as possessors of these works would be incomplete if the extraction of gas from coal could be looked upon as a speculative industry; or, indeed, as being attended with anything short of an almost absolute immunity from risk. Consequently, it is not at all surprising that Corporations should bring to the discharge of their duties as gas purveyors a desire for improvement, it is true, but for such improvements only as may have received the sanction of experience and tradition. Nor is it any less surprising that, under the influence of a susceptibility to criticism which is at once the strength and the weakness of popular institutions, this disposition to narrow the purview of their administration should survive long after a more intimate acquaintance with the details of the manufacture not only will have made it apparent how much is dependent upon practised and intelligent supervision, but must also have suggested how much is to be anticipated from observation and research, stimulated and sustained by a higher knowledge of scientific truths. If this much can be said in extenuation of what, speaking, as a matter of course, in a general sense, and certainly not from my own individual experience, may be described as the prevailing tendency of Corporation influence, is it unreasonable to expect that a more just appreciation of the art and of its resources will follow upon the advancement of public spirit, and an increased sense of responsibility with regard to municipal affairs?

If proof were desired of the uncertainties by which even the most experienced gas makers find themselves to be surrounded, or if we should wish to know in what directions it is likely that profit and advantage will accrue from the encouragement, not alone of a spirit of inquiry, but also of a higher standard of professional qualifications, we have only to turn to the chronicles of passing events. While, for example, it is a matter of common knowledge that temperature controls the principal operations comprised in gas manufacture, and governs their economy with an almost absolute force, how lamentably small, in comparison with its acknowledged influence, is our stock of reliable data as to its effect under varying conditions. Probably this was never made more apparent than during the discussion that followed the publication last autumn, in the columns of the JOURNAL OF GAS LIGHTING, of the article by Mr. George Livesey, on the "Economy of Carbonization." Started by the enunciation of a proposition not very far removed from elementary, in its conclusion it was felt that nothing had been concluded. It embraced perhaps a much wider range than had been contemplated by its originator, and yet the most conspicuous feature of it was the scarcity of facts, in support of the ideas, which it elicited. Nevertheless, it served a very useful purpose, by bringing into convenient juxtaposition opinions representative of the most opposite of proclivities. Speaking broadly, on the one side was sought to be disparaged the exercise of scientific skill in carbonizing; while, on the other, its importance was as stoutly maintained. It does not seem possible to extend towards the former view any great amount of sympathy; but it is not to be denied that, in existing circumstances, there is much that is favourable to the arguments by which it was supported. It is not the premisses so much as the conclusion arrived at by its advocates, that seems to be at fault.

In these fortunate times, when not unfrequently the entire cost of the coal is covered, or nearly so, by the value of the residuals, it would appear upon first thought to be a very small matter indeed, in comparison with the ready saving that may be effected by a judicious selection of materials, whether the return per ton be 500 feet more or less; and when the higher result is only to be obtained by the employment of a more expensive material, whether of coal or cannel, or a mixture of the two, it ought not to be very difficult to decide upon its comparative economy. Assuming, as we may do for all practical purposes, that the value of the residuals remains the same, the issue in such a case is narrowed to one of difference between the increase in cost of material on the one hand, and the saving effected in labour, wear and tear, and interest on capital outlay for retort plant on the other—both calculated at per thousand cubic feet produced. Certainly, when purchasing coals, it will not do to rely upon a high yield of gas, to the exclusion of other considerations, because the almost invariable concomitant of this is a disproportionately increased price; and hence it will be found, more often than not, that the most economical all-round results have been secured by the use of the cheapest suitable material, although in doing so the gas manager may have to run the gauntlet of criticism of no very enviable kind. As a matter of course, there are reasonable limits to this, as there must be to every method of selection, which each one may be left to define for himself, according to circumstances—such, for instance, as the value of coke in his particular locality, or the distance from it to the coal-fields—but upon the broad question of principle, I apprehend that there is little room for difference of opinion. To base our selection of coals solely upon their ascertained commercial value for gas-making purposes, and not with an eye to carrying on a kind of competition with our neighbours for the greatest make per ton, is neither more nor less than to assert our claim to the exercise of an untrammelled judgment upon matters of vital importance to the prosperity of a gas undertaking; and, as such, is secure, I venture to think, of a ready and complete acceptance.

With this general agreement, however, our difficulty with regard to the views under consideration may be said to commence; the correspondence having made it clear that the tendency to undue reliance upon commercial instinct is not altogether confined to the comparatively uninitiated. But what does it amount to? That benefit has followed, and is

likely still to follow, the assertion of what is, after all, little more than an implied principle of good management, no one will care to dispute; but that this justifies a diminished respect for skill applied in the retort-house, few, I trust, will be disposed to admit. On the contrary, it could scarcely be a difficult matter to show, by illustrations derived from current experience, that the familiar and oft-quoted axiom, that "dividends are made in the retort-house," is, in the warning and encouragement it conveys, as true to-day as it undoubtedly was true when first uttered. At all events, the opposite opinion may be accepted as an unconscious and, on that account, most valuable tribute to the average excellence of modern carbonizing arrangements; for this alone could induce so happy a feeling of confidence in results under all conditions. But by what means has this excellence been attained? Do we not know that it is not the achievement of a day or of a year, but that it has been built up by continuous and persistent effort, by patient attention to details and observance of effects? It is, of course, quite possible that our labour may have been expended for naught; or rather, that it has been pursued in this direction at a sacrifice of other advantages; but if a comparison of results should make it clear that the reverse has been the case, ought we not to derive from it encouragement to fresh enterprise, and confidence in following the lead of those who may claim to have established a further and perhaps more notable advance?

Most of us will have the materials for such a comparison ready at hand. Individual experience must be the best guide to future action. And will not this experience, more often than otherwise, furnish a record of steady progress in the attainment of what were at one time held to be next to impossible results? How frequently has it not happened that each succeeding year has been marked by an improvement in the make per mouthpiece, or in the yield per ton, with a proportionate diminution in the charges for labour, and with little apparent addition to the fuel account, or falling off in the receipts for residuals. It is, however, only reasonable to suspect that to such economy there must be a limit. Our perplexity is to find out this limit, which does not appear to be reached by the exhaustion of our resources for the prevention of waste. You cannot, it has been said, with an assumption of practical wisdom, get more out of a ton of coal than there is in it. We should be in a position to appreciate the observation better if we knew exactly what a ton of coal is capable of yielding, or it might even be regarded as the perfection of truisms if only we had arrived at a knowledge of the precise methods by which the most economical results are to be secured. But these are still the objects of our search. We continue to be in doubt as to whether the tendency of a higher heat is to increase the volume of gas at the expense of its quality, or whether it is to be considered simply as a means for quickening production; and also as to its influence upon the formation and composition of tar and of impurities.

These are all questions which are involved in so considerable an amount of obscurity, that only a few facts concerning them are at all plainly discernible. One of these, however, is of primary importance. That rapid production may be compassed in a remarkable degree by the application of a high heat, is in perfect accord with common experience; but that deterioration in quality does not follow as a necessary consequence, has not been by any means so generally accepted or understood. The opinion of Dr. Schilling, therefore, upon this point is deserving of our most careful consideration, because it is that of one who has devoted much time and attention to the study of this subject; and also because it is endorsed in a very practical manner by nearly every other leading gas engineer in Germany. Go almost where one will in that country, evidences are to be met with of a deeply rooted faith in the efficacy of high heats, and this can only be accounted for by the circumstance that no such deterioration is found to ensue. Dr. Schilling, indeed, is careful not to claim for the system with which he has so successfully identified himself, any greater merit, as regards the point under consideration, than that of improving the production per retort; but others, both in this country and elsewhere, are not slow in ascribing to it still higher virtues. According to these, it affects favourably not only the productive capacity of the retort-house, but also the yield, or the quality, or both, of the gas produced. Further evidence as to this, which, to be conclusive, should embrace the commercial value of the resultant tar, is much to be desired; but, in the meantime, the negative testimony, if such it may be called, of the German gas makers, supported as it really is by the results thus far of our own practice, cannot but be accepted as satisfactory by those who are desirous of emulating their achievements.

In one particular—namely, in the saving of retort space—the advantage of high heats, as developed by the "generator" system of firing, is so obvious as scarcely to call for special remark. I am, however, tempted to bring under your notice one out of several illustrations of it which I met with during the autumn of last year, because it happens to bring into contrast two systems of retort management, the least advanced of which cannot be said to have received general recognition amongst us. At Dresden the new works in course of construction were originally designed with settings of six retorts, the furnaces being adapted for what has been called "hard firing," and the yield relied on 6000 cubic feet per mouthpiece. But in the interval which not unfrequently occurs between the conception of an undertaking and its commencement, the Engineer to the Municipality (Herr Hasse) had been able so completely to satisfy himself of the practicability and comparative economy of the generator system, that settings of nine retorts each, heated by generator furnaces, one to every two settings, in place of six, and occupying only the same ground space as the latter, were eventually determined upon. The yield from these is estimated at 8000 cubic feet per mouthpiece, or, per setting, exactly double that which was formerly obtained, and upon which the previous estimate had been based; the net result being that the retort-houses, as now constructed, while of the same productive capacity, are only about one-half the size that was at first thought necessary. It is evident what a relief the establishment of this system might prove to be in some of our overcrowded works, where it might tend to prolong the life of plant, the productive capacity of which has already reached the ordinarily accepted limits.

The influence of temperature upon the formation of impurities, amongst which ammonia may be reckoned, is a study that has hitherto been all but neglected; and yet how much might it not be found to contribute to a settlement of the comparative economy of high and moderate yields. It is not without value to know, for instance, that carbonic acid is evolved most rapidly at the commencement of a charge, when the heat within the retort is at its lowest; while carbonic oxide is formed in increasing abundance as the charge becomes worked off, and the heat is proportionately greater. But it might prove of much more importance, by putting it into our power to lighten the labour and cost of the subsequent process of purification, if we did but know, with anything like distinctness, the conditions most favourable to the formation of sulphur compounds. Above all, the production of ammonia is in the highest degree worthy of investigation; not alone on account of its rising value as an article of commerce, but also because of the hopes that are very properly based upon its known adaptability as a most facile purifying agent. It is not by any means certain that the combination within the retort of the two elements of which ammonia is composed is beyond our control; recent experiments tending to show that this is accelerated by high heat, or, at all events, that by far the largest proportion of ammonia is produced towards the end of the process of distillation. This, if confirmed, would furnish an additional argument in support of what may be called the "advanced" method of carbonizing; and, in conjunction with other considerations of no less weight, affords reasonable grounds for inferring, that the position taken up by the defenders of that which is now styled a moderate, but which not so long ago was looked upon as a high heat, is, to say the least of it, by no means impregnable.

In quite another direction this uncertainty about temperature still pursues us; but this time it is not the attainment of effect by its means, so much as the means by which heating effect may be attained, that form the objects of our search. During the last few years the heating properties of coal gas have come to be extensively recognized, and its advantages in this respect are regarded as no mean security for the permanence of our industry. It is, consequently, of growing importance to determine the correct principles upon which heating appliances ought to be constructed, in order to obtain from them a maximum effect; but there are indications of danger to be apprehended from overrating the resources of science to this end. It is evident that no good can possibly result from an undue exaltation of the heating properties of coal gas; nor can anything but serious mischief result to the cause we all have so much at heart, from the dissemination, however unintentional, of inflated hopes. With the object of avoiding this, it is above all things desirable that the

heating power of coal gas should be definitely ascertained; and we may therefore hail with considerable satisfaction the promise of authoritative information held out to us by the papers of Dr. Adams and Mr. F. W. Hartley.

Now, in the choice of a stove, or in deciding upon the details of its construction, we may very properly address to ourselves this rudimentary proposition: What are its functions? Is it to be considered as a means for developing or increasing the heat afforded by the combustion of gas, or must it be regarded simply as an instrument by which we are enabled to control the heat for our purposes, and carry off the products of combustion? I apprehend that only one answer to this is at all possible, or is capable of being sustained. There cannot be more than one source of heat, and that is the combustion of the gas; though whether its development is favoured by one burner more than another may, to some extent, be an open question. But as regards the apparatus itself there is little room for conjecture or uncertainty. It may be made to assume any possible shape, or be so contrived that its full thermal effect takes the form of a current of heated air capable of being measured with the greatest exactness; and yet its superiority over other appliances, depending for their effect to a greater extent, perhaps, upon the ordinary means of radiation, will not have been made manifest.

It is by no means clear that any ordinary burner, employed for the purposes of illumination, will not produce a greater heating effect, proportionate to the consumption, than the most elaborate gas-stove that has yet been produced. In a certain room, for example, there is a gas-fire and a three-light chandelier. The gas-fire is a modern contrivance, although I do not instance it as a model of economy, for it consumes 34 cubic feet per hour; the chandelier is fitted with burners of a very common kind, consuming together from 12 to 14 cubic feet per hour. A higher temperature is produced in the room—more than double the effect, in fact—by the chandelier alone than by the gas-fire alone; in other words, the latter requires fully five times as much gas as the former, to produce the same result. This is scarcely difficult to account for. The position of the gas-fire against one side of a square instead of in the centre counts for something in favour of the chandelier; then there is the absorption of heat by the sides and back of the fire, most of which is lost for useful effect; but more than all, there is the inevitable large percentage carried away with and by the products of combustion. This explanation is so simple as to be scarcely worth mentioning, were it not for the lesson that it teaches, and which is so frequently lost sight of. With the chandelier, as a matter of course, the whole of the heat is given off within the room, and consequently the highest economical result is obtained; but with this attendant drawback, that the products of combustion are not got rid of.

In the construction of a stove, then, the object that should be aimed at is to render available as large a proportion as practicable of the heat, by carrying off the products of combustion with the smallest percentage of loss. With this end in view, economy in design is usefully promoted by the application of the principle of an induced current of air, after the manner of an annular condenser; and this appears capable of extended application. In the highly important work of house ventilation, for instance, it is probable that a very wide field is open for the employment of coal gas, because, by its means, this is susceptible of easy and satisfactory accomplishment. What are the conditions of efficient ventilation? They are, that the vitiated air shall, by some continuous process, be withdrawn and replaced by an equal supply of fresh, without inconvenience to the occupants of the apartment or dwelling. Ordinarily, as we know, this is a matter that is left entirely to chance, fresh air being regarded as an intruder, to be kept out—in cold weather, at any rate—at all hazards. But this need not be. No one will dispute its value, if it can be admitted without injury or annoyance. A Ritchie, or any stove of similar construction, is capable of being turned to admirable account for this purpose. All that is required is to connect the vertical air-tubes alternately at the top and bottom with pipes leading to the exterior of the building. When this is done, and the stove lighted, two air currents will be set in motion, one proceeding inwards, and delivering fresh air, warmed in its passage through the stove, and the other outwards, expelling air that has become vitiated. Mr. Lawson Tait, of this town, has recently introduced a very simple modification of this arrangement, suggested, I believe, by what is known as the "Tobin" tube, and which is capable of being most cheaply and at the same time very effectively applied. It will be found described in Mr. Tait's pamphlet on "Bedroom Ventilation," a little work which is deserving of study by all who are interested in extending the uses of gas.

Suggestions have been made for increasing the heating power of gas by raising the temperature of the air supply; though whether, in this respect, any analogy exists between gas combustion and the process of iron making, in which the introduction of a hot blast has proved so eminently successful, is at present a matter of almost pure speculation. Less doubt, if anything, surrounds the action of hot air in the development of illuminating power; but even with regard to this the evidence has hitherto been conflicting. Recently, however, attention has been directed to the regenerative burner of Herr F. Siemens, of Dresden (samples of which, I may mention, are to be seen at the Windsor Street works), by which most important results are said to be achieved. We shall hail with infinite pleasure any confirmation of them, as indicating an entirely new departure, the significance of which it would be difficult to over-estimate.

It is not surprising that the increasing appreciation of the convenience of fuel in a gaseous form should lead to the revival of proposals for the supply of a cheap gas to be used exclusively for heating purposes; and it may not be altogether futile to imagine it as one of the resources open to gas makers, by which the periodical embarrassment arising out of large accumulations of coke may be avoided. It is not, however, to be expected that the anticipations of success indulged in by the advocates of these projects can be fully realized. The prospect of a duplicate system of mains, services, and fittings is repugnant to our notions of economical distribution; although finding favour, if I am rightly informed, on the other side of the Atlantic. One powerful objection, likewise, is to be found in the fact that coal gas is already in almost every house, and every consumer has it in his power to help forward that good time to which we are to all appearance hastening, when it shall be applied with economy to all the purposes for which heat is required. Every penny per thousand feet taken off its price increases its chances of permanent employment in this direction, and removes it to a less measurable distance from competition with carbonic oxide. Apart from this, however, the subject is an important one, too, from its bearing upon the details of our manufacture; and we are, therefore, fortunate in being able to look forward to its treatment this evening by one of its greatest and most distinguished authorities.

While continuing in doubt as to the practicability of such projects, of which probably during the next year or two we may hear more, they furnish a hint which need not be lost sight of in the ordinary process of gas-making. Dr. Wallace has proposed that this should be supplemented by means for the separation of the gases given off towards the end of the charge, which are admittedly of much less value for lighting than for heating purposes. The provision of duplicate hydraulic mains, with valves for reversing the current of the gas at a given period, would seem to introduce a most undesirable complication of plant, and, for other reasons, is clearly inadmissible for the end Dr. Wallace has in view; but it points to a way by which the quality of the gas might be completely controlled, without recourse being had to any expensive enriching material. In substance, the idea bears some resemblance to that which formed the subject of an unsuccessful patent taken out in this country about four years ago, but in its present more practical shape it is said to have been applied at some German works; the gas issuing from the secondary hydraulic main being separately condensed to extract from it the valuable tar and ammonia, and then utilized in the retort furnace. It is not unreasonable to expect that economy should result from such a method skilfully applied; although not likely to recommend itself to those whose first consideration is a large yield of gas per ton of coal carbonized.

The lamented death of Mr. F. J. Evans, who was a member of this Association, which occurred shortly after our visit last year to the grand works with which his name is inseparably associated, has severed a prominent connecting link between the past and the present of gas manufacture. His long professional career embraced a period fruitful in events of a permanent and decisive character, in the shaping of which he bore a distinguished part. The history of the Company with which he was for so many years officially connected has been a somewhat chequered one. The struggles and vicissitudes in which he participated were essentially such as are everywhere to be met with upon the road to solid and enduring success; the ultimate triumphs in which he shared were the fitting rewards of sagacity and enterprise. Perhaps of all the changes that occurred during his time, the one

possessing the most abiding interest for us is that which he was mainly instrumental in effecting. The transference of the manufacture of gas to a distance from the Metropolis was conceived in a happy moment for the fortunes and prestige of his Company, and not less happy was the manner in which it was carried into effect.

The works at Beckton have been justly designated "the most magnificent establishment of the kind in the world;" and if our admiration at the skill that is everywhere displayed in them should have a tinge of disappointment, this mingled feeling will not have been engendered by any sense of incongruity or incompleteness. It will have been occasioned solely by the unwelcome conviction, brought home to us with all the impressiveness of magnitude, of the apparent hopelessness of seeking for any radical improvement in gas-making appliances, having reference chiefly to retort-house plant. Here, it may be said, is unlimited scope, manufacture upon a gigantic scale, and every inducement to a new and economical departure; but this has not been taken. Yet ought we, even in the face of such overwhelming evidence, to acknowledge its impracticability, or cease asking ourselves why it is that, while in almost every other direction advances continue to be made commensurate, or nearly so, with the enlargement of our operations, retorts, within the limits of a few inches in size, remain the same; our largest works being, in this respect, little more than a multiplication of such as are infinitely less, and possessing over them little or no advantage in point of economy of production.

Can it be that every alternative has been tried, or that none is possible to the present costly method of carbonizing more applicable to the large quantity of coal with which we are now accustomed to deal? Some will say that machinery is a remedy; but machinery, at its best, leaves much to be desired. Is there nothing to be learned from kindred industries? We know, for example, that the manufacture of metallurgical coke, in which the labour per ton of coal is infinitely less than in that of coal gas, is becoming assimilated to the latter; the gaseous products from the coke-oven being treated, as regards exhausting and condensing, in much the same way as are those from a gas-retort. I do not go so far as to say that a coke-oven, even of the most modern kind, such as is employed in several parts of France, and in its earlier form by the Paris Gas Company, would be found applicable in its entirety to gas-making; or that other considerations, into which it is impossible now to enter, may not outweigh that of economy of labour. But it might offer a clue to the direction in which improvement should be sought. At all events, it seems only reasonable to suggest that we cannot too soon or too intimately become acquainted with methods so nearly allied to our own, if we are sincerely desirous of reducing a most considerable and wasteful item of the present cost of gas-making.

I had hoped that time would permit me to say something upon other subjects of no less interest and importance. Notably that of purification in closed vessels is one towards which hopeful glances continue to be directed, although sustained as yet by little substantial encouragement. Still, the different processes that during recent years have been presented to our view point to something more than a mere repetition of former failures. They are unmistakeable evidences of an increasing spirit of inquiry, and go far to show that this most desirable reform is not beyond the reach of skill and enterprise, and that no one need despair of its ultimate accomplishment.

But I must not further pursue these tempting topics. I am anxious, by way of conclusion, to direct your attention to a widely different matter—to a work which, a few years ago, was commenced, under the auspices of the Association, at the instigation mainly of one of our Past-Presidents, Mr. W. J. Warner, and which has since moderately prospered. It will be remembered that considerable objection was, upon various grounds, taken to the formation of the Benevolent Fund. It was believed to be unnecessary, or that it might to some extent inspire the needs which it was intended to relieve. But the cases that were speedily brought under the notice of its Committee effectually disposed of these objections, and it soon became apparent that a much larger income than was available could be usefully and beneficially dispensed. Accordingly, measures were taken to give greater prominence to the fund, with the gratifying result, last year, of a substantial increase in the amount of subscriptions. This has enabled the Committee to provide a larger measure of relief for the ensuing year, though not so large as would be justified if their income could be felt to be of a more permanent character. To impart to it this desirable permanence, it is hoped that the fund will henceforth enlist the support of a greater number of subscribers. It has no ambitious programme to fulfil. Its work has no pretensions to that of a life insurance or provident institution. It is not for the encouragement of the improvident, neither is it for the benefit of the intemperate or the careless; these have no claims upon our sympathy. But when misfortune has done its work—when, perchance, the breadwinner is struck down without having had the opportunity of providing for those who are dependent upon him; or when the storms of adversity have broken upon a head bowed by the weight of years—then, to the home of the desolate, or to the couch of the weary, speeds our message of comfort and of healing.

PHOTOMETRICAL RESEARCHES.

In the last number of the *Journal de Physique*, Mons. A. Cornu commenced a series of observations on "Photometrical Studies" made by him, in consequence, as he says, of having found the necessity, in many branches of physical science in which he has been engaged, for some simple arrangement of apparatus for measuring luminous intensities. He announces the completion by himself of various photometrical and spectro-photometrical appliances which he believes will prove useful in many ways, both in physics and astronomy. These arrangements are based upon the property of lenses, discovered and utilized by Bouguer, that the form of a focal image is independent of the dimensions and form of the aperture of the lens, and of an intensity proportional to the surface of the aperture.

In the first form of apparatus, intended for the comparison of the intrinsic brilliancy of real images received upon a white screen, M. Cornu makes use of two achromatic object-glasses, as similar in all respects as possible, of which the principal optical axes cross each other at about their common focal distance. Each of these throws upon a white screen the image of a small rectangular diaphragm placed at the conjugate focus from the screen, and behind each of the diaphragms respectively is placed one of the two sources of light, or rather the portion of the luminous object of which the relative brilliancy is to be compared. The equality of the two images is obtained by varying the area of one of the objectives, and for this purpose each of the glasses is covered by two metallic plates sliding one over the other by the action of a pinion working in two ratchets. The orifices in the plates are square, and by revolving the pinion the two perforations are made to allow a smaller or larger amount of light to pass. As the holes are placed diagonally with each other, the movement of the ratchets always preserves a square opening, and as the pinion is fixed while its rotation causes the two plates to approach or separate the holes, it follows that the centre of the square opening is always in the optical centre of the lens. This is what is generally known as the "cat's-eye" arrangement of sliding screens.

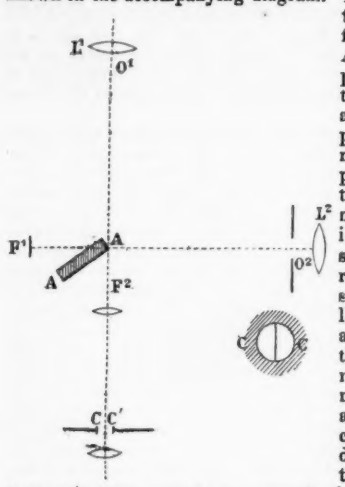
To measure two lights comparatively, the light-sources are brought as close as possible to the rectangular diaphragms, and their position is then regulated by two conditions. (1) The images on the screen should be as clear as possible, to effect which they must be advanced or receded by a convenient distance. (2) The opposite edges of the two images should coincide, so that the line of separation between the two fields may become invisible by the equality of the respective brilliancies. The points of luminosity which are to be compared must then be selected, and their images projected on the screen so that the edges are uniform. All being ready, the square diaphragm of the objective corresponding to the feeble light is opened to the full dimensions, and equality of the images is obtained by operating with the rack and pinion of the other diaphragm until the line of separation disappears. The diaphragms being provided with conveniently graduated scales to show the extent of the openings, the illuminating power is found by taking the inverse ratio of the squares of the graduation. The means of measurement may be infinitely varied by slightly diminishing the area of the diaphragm of the weaker source of light. A fresh point of departure is thereby attained, and by measuring the relative power of the two lights on this basis, a means of correcting the first result is obtained, the square of the difference thus shown being inversely proportionate to the relative power of the light, and so on. When the sources of light are very intense, the apertures of the two objectives may be diminished as required, to decrease the brilliancy of the images on the scale in order to better judge of their relative value.

It may happen that the two lights are not of the same colour; in which case their comparison on a plain white screen is not precise. Similarity may, however, be restored by examining the two images through a coloured glass of a tint having some relation to the use which is proposed to be made of the lights. To eliminates light inequalities of apparatus, the sides may be transposed; that which was at first used for the stronger light being used for the weaker, and *vice versâ*. This is easily done in consequence of the construction of the apparatus, for in reality each part is fixed on the end of a large cylindrical pillar, which slides on a fixed internal rod. This arrangement permits of the principal axis of the objective being inclined, and of its being raised and lowered at will. As an instructive example of observation, the comparison of the intrinsic brilliancy of the middle of the flame of a flat-wick petroleum lamp with that of the same flame viewed edgewise may be named. It will be found that the brilliancy of the edgewise flame is more than ten times superior to that of the flat side of the same flame. To make this comparison, an auxiliary source of light is taken (such as a

moderator lamp with a double current of air), and for the point of comparison an apparently homogeneous part of the flame is chosen, particularly the edge, which possesses a high and constant brilliancy. On the other side the petroleum lamp is fixed upon a support capable of revolving so as to present the side or edge of the flame in any direction. The brilliancy of the two aspects of the flame may thus be compared with that of the standard employed. The method of using an auxiliary or standard lamp is, in M. Cornu's opinion, to be generally preferred to that previously described, since it eliminates all inequalities of construction of diaphragms or of transparency of objectives.

Another form of apparatus, called by M. Cornu the microphotometer, dispenses with the white screen. The preceding arrangement, modified by the substitution of a sheet of oiled paper or clouded glass, permits of the two images being observed from behind with the help of a magnifying lens, thus making the operation more easy and precise. Even this screen might be suppressed, and the images observed directly, these being, under such circumstances, infinitely more delicate and vivid; but as the principal axes of the two lenses form an angle of 15 degrees, the two images could not be observed simultaneously in the same position of the eye, because the two ocular rings are separate. The comparison is therefore difficult, and can only be rendered accurate by making the two axes of the objectives coincide. To accomplish this M. Cornu at first employed the well-known means of a plate of plain glass at 45 degrees, which allowed the rays from one objective to pass by transmission, and brought forward by reflection the rays from the other objective. By suitable means of regulation the two actual focal images may be easily obtained in the same plane, to be observed by a hand-glass, or a microscope of low power. The unequal proportion of reflected and refracted light does not permit, in this case, of a direct comparison of two light-sources; the auxiliary light must be used. The employment of this plain glass plate results in two possible inconveniences; it partially polarizes the two bundles of rays—the one by reflection, and the other by refraction. If, therefore, the lights to be compared are themselves partially polarized in an unknown plane, the relations of the intensities are altered in proportions which might be ascertained at the price of various subsidiary operations which would complicate the method. The second peculiarity is the influence of the two surfaces of the plain glass, each of which gives a reflected image of the source of light. There will thus be two images in slightly different focal planes. One of these may be got rid of by using a glass of sufficient thickness, or giving a slight inclination to the two faces. On the other hand, this arrangement lends itself to several physical and astronomical purposes not readily accommodated by the preceding method.

In his defining photometer M. Cornu has adopted the arrangement shown in the accompanying diagram.



The plain glass is replaced by the plate of black glass, A A, finished off by a straight edge, A, normal to the plane of the principal axis of the objectives. The focal planes, A F^1 and A F_2, are arranged to pass exactly by this edge. A microscope of low magnifying power (from 25 to 50 diameters) permits of the simultaneous inspection of the two images of the two luminous sources. By regulating as required the position of the sources of light, the two lighted areas to be compared are brought into contact with the edge of the glass. To render the comparison still more complete, the two areas are isolated by the aid of a circular diaphragm, C C′, introduced into the optical plane of the microscope. The visible field will then consist of a small circle equally divided by the almost invisible line formed by the edge; one moiety will show a constant intensity, the other will be variable by the help of the photometrical screen. In these circumstances, and above all if care has been taken to bring down the intensities to a certain limit, the eye acquires such great sensibility, that the smallest differences of composition of the lights translate themselves by a difference of colour which becomes irksome in the estimation of equality; none but sources of absolutely similar or monochromatic light give by this means a completely satisfactory impression of equality. The areas for comparison may be extremely minute; if the focal images are clear, and obtained by the aid of achromatic objectives, the microscope, acting as an eye-piece, will magnify them to any extent, and from the apparatus being thus applicable to the measurement of the brilliancy of extremely small images it has been called by M. Cornu the microphotometer.

This kind of photometer measures not only the intrinsic brilliancy of the focal image which is projected in the plane A F^1, it also allows of the measurement, when the objective L^1 is removed, of the lighting power exerted by any source whatsoever in the plane A F^1. In fact, the intensity of a luminous wave tangent to the plane passing by the edge A and the path A F^1 may be measured. It may be observed that this photometrical apparatus only fulfils its duty when the pupil receives all the light which has passed through the apertures of the lenses, or which comes from the luminous source; it is therefore necessary to verify, by the use of an additional magnifier—(1) that the minimum square aperture of the photometer L^2 is entirely visible in the ocular ring; (2) that the aperture of the objective L^1, or the image of the light-source, is also completely visible and concentric with the image of the square aperture. This form of apparatus is applicable to the measurement of the intensity of different parts of the spectrum by the use of a spectroscope in conjunction with the photometer.

M. Cornu promises further communications on this highly interesting subject, which is now attracting much attention in view of the admitted imperfection of existing kinds of apparatus.

MECHANICAL ENGINEERING.*

THIS latest addition to the admirable Weale's series of rudimentary scientific and technical manuals is worthy of its place among the well-known little green books, some of which are to be found in the library of every practical student. The present is an abridgment of the author's more important work on the subject, published some years since; but the text has been re-written, with the object of including as many as possible of the modern improvements in mechanical work. Still the chapters are slightly disjointed, thereby betraying their origin, and the little volume shows clear evidence of an attempt to crowd within its covers an amount of matter which could scarcely be satisfactorily contained in a much larger book. This, of course, leads to other evil effects besides cramming, and it must be deemed the author's misfortune rather than his fault, that the introduction of some particular information on a technical point occasionally leads the reader to expect more details of a similar character in respect of something else, which are not to be found. Mr. Campin commences by describing some of the more ordinary operations and principles of metallurgy, which is, however, dealt with in a very rudimentary and superficial manner. We never find this part of the necessary instruction of a student satisfactorily treated in books of this class. Authors of all manuals of construction-trades think it incumbent upon them to describe the reduction of ores, puddling, steel-converting, &c., and to illustrate the principal apparatus used in such processes, but in a purely encyclopædic way, and in the most general terms; so that any two books, one treating, say, of clock-making, and the other of boiler-making, contain introductory chapters of similar character. This is a mistake, for a student of mechanical engineering naturally wants to know not merely how the raw materials he uses are produced, but also how the different trade classes of metal are made up, and what qualities he should require in his materials, what to avoid, and how to detect imperfections. These details are of the greatest importance to students and older practitioners, but they are seldom to be met with in even professedly trade manuals, although it must be admitted the author has tacked on to the present work a chapter that is intended to supply this want, which, however, it does only partially. Mr. Campin carefully points out the tendency of modern smiths' work in the direction of hydraulic pressing and shaping in preference to the older method of hammering, and describes how some classes of work are finished in the new style. In treating of moulders' work, Mr. Campin gives us a French spelling of the substance which is frequently found in castings where iron should be, and refers to the disastrous Tay Bridge affair as a warning against the extensive use of what he calls *beaumonteague*. We never saw the word spelt in this way before, but as it is a term not likely to find its way into specifications, a little uncertainty as to the orthography is of small moment. The author goes on to describe the principal kinds of machine tools, and gives some useful hints respecting their use. After this follow a few chapters on force, the principles of machine construction, and matter in motion, the latter being very clearly discussed; though we should like to have seen the doctrine of the conservation of energy brought forward more conspicuously, since it is so generally found that students and skilled mechanics are continually being led to waste their time and energies in the search for perpetual motion. Steam engines and boilers, and their subsidiary fittings and appliances, are dealt with in the last chapters of the book. Mr. Campin brings his collection of examples down to very recent innovations, and does his best, in the limited space at his disposal, to draw from them information which will be useful to the readers for whom he principally labours. Altogether we may say that this is a very useful little book, and no student of practical mechanics can afford to despise its teachings.

A QUALITATIVE TEST FOR CARBON DISULPHIDE AND CARBON DIOXIDE IN COAL GAS.—According to *Science*, at the meeting of the American Chemical Society on the 6th ult., Dr. T. O'Connor Sloane gave the following description of a new qualitative test for carbon disulphide and carbon dioxide in coal gas:—A piece of caustic potash, a few millimètres long, is added to 10 or 20 cubic centimètres of alcohol, into which a piece of potassium carbonate has been added. The alcoholic solution of potash is placed in a suitable absorption tube and a cubic foot or more of gas passed through it. It is then removed from the absorption apparatus and poured into a test tube. If the gas contains any carbon dioxide, an oily-looking layer, nearly colourless, of a solution of potassium carbonate will underlie the alcohol, which latter will have acquired a reddish colour. The alcoholic solution, which, if any carbon bisulphide be present, will contain potassium xanthate, is boiled and tested for hydrogen sulphide. Another method is to add an excess of a copper salt, filter out the precipitated copper compounds, and pour ammonia through the filter-paper, when a highly characteristic yellow precipitate of copper xanthate will remain behind.

* "A Practical Treatise on Mechanical Engineering." By Francis Campin, C.E. London: Crosby Lockwood and Co. 1881.

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